DOCUMENT RESUME

ED 127 162 SE 021 192

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TITLE An Experimental Study of the Placement of Classification Skills in the Science-A Process Approach Curriculum Employing Piaget's Theory of Cognitive Development.
PUB DATE Apr 76
NOTE 22p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (49th, San Francisco, California, April 23-25, 1976); Contains some broken type

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Classification; *Cognitive Development; Curriculum; *Educational Research; *Elementary Education; Elementary School Science; Learning Theories; Science Course Improvement Project; Science Education
IDENTIFIERS *Piaget (Jean); Research Reports; *Science A Process Approach

ABSTRACT

The purpose of this study was to investigate whether success in the Science - A Process Approach (SAPA) process of classification designed for primary grade children is contingent upon the children's developmental level as defined by Piaget's theory. The investigators sought to determine whether children who had reached the concrete operational stage of intellectual development are more likely to succeed on SAPA exercises requiring multi-classification ability than their primary classmates who are at the defined pre-operational level. Thirty children were assigned to either pre-operational or concrete operational on the basis of two diagnostic instruments and their mental ages were determined with another instrument. Matched pairs, one from each developmental state, were formed with each child having a mental age score within one standard error of one another. These matched pairs were assigned randomly to one of two teacher instructional groups and taught nine sequentially-arranged classification exercises as prescribed by SAPA. A two-factor analysis of variance with developmental level crossed with teachers was used to analyze the scores from the nine individually administered competency measures accompanying the SAPA classification exercises. The concrete operational group performed significantly better than the pre-operational group in three exercises requiring hierarchical classification and in four exercises requiring exhaustive sorting. (Author/MH)

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AN EXPERIMENTAL STUDY OF THE PLACEMENT OF CLASSIFICATION SKILLS IN THE SCIENCE-A-PROCESS APPROACH CURRICULUM EMPLOYING PIAGET'S THEORY OF COGNITIVE DEVELOPMENT

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A paper presented at the National Convention of the National Association of Research in Science Teaching, San Francisco, April, 1976.

SE 021 192

INTRODUCTION

Educators engaged in curriculum improvement in the last decade have been concerned, not only for what is taught in elementary school, but also, for applications of learning theories as espoused by Piaget, Gagne, Bruner and Ausabel. A diligent pursuit of implications of these theories to such vital issues as sequencing instruction and concepts children can understand at various ages has been of major interest to researchers. Almy (1964, p12) writes,

> "Emphasis on education in relation to human development has switched from an emphasis during 1930's in habit training, to preoccupation with social and emotional aspects of development, to concern with personal and subjective aspects of child behavior, to (most recently) the intellectual aspects of development" (p. 12).

The revival of interest in the theories of Piaget with the emphasis on a definite order of stages in the cognitive development of a child's concepts seems to hold real possibilities for a more rational approach in determining a sequence of learning experiences in science.

Along with theoretical exploration of the concepts of area, length and volume, Inhelder and Piaget (1964) have hypothesized a sequence of classificatory behavior on the part of the young child. The studies of Kofsky (1963) and Allen (1967) correlated sufficiently with Piaget and Inhelder for one to assume that classificatory skills develop in children from single sorting through multiple classification to hierarchical classification and class inclusion.

Concurrent with the educator's interest in Piaget's findings has been the development of several innovative elementary science programs. Under the auspices of the American Association for the advancement of Science, Science-A Process Approach (S-APA), process-centered curriculum, was developed consisting of Part A through E of which A is usually

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Paper presented at the national meeting of National Association for Research in Science Teaching held at San Francisco, April 19-20, 1976.

placed in kindergarten, and the other parts in subsequent grades. SAPA's 1967 edition was made up of twenty to twenty-six hierarchially-arranged exercises to be taught throughout the school year.

Classification is one of the eight intellectual process skills proposed for the S-APA's primary grade science curriculum. Eleven exercises comprise the classification hierarchy of S-APA's 196' edition. The classification lessons are taught sequentially from single sorting in kindergarten and to the more complex skill of hierarchical classification introduced in second and third grade.

STATEMENT OF THE PROBLEM

The purpose of this study was to investigate whether success in S-APA's classification exercises, designed for primary grade children, is contingent upon the children's stage of development as defined by Piagetian theory.

More specifically, the investigator sought to determine whether second grade students who have reached Piaget's concrete operational stage of intellectual development, characterized by the ability to perform multi-classification tasks, are more likely to succeed on S-APA exercises requiring multi-classification ability than their second grade classmates who are at the pre-operational developmental stage.

The problem was facilitated by the exploration of the following:

1. Comparison of the performance of second grade students defined as (1) pre-operational and (2) concrete operational on nine of S-APA's classification exercises.
2. Comparison of the teachers' effect on the performance of second grade students in the (1) pre-operational and (2) concrete operational stages.

3. Analysis of the interactions of the foregoing two effects, developmental stage and instruction.

ASSUMPTIONS OF THE STUDY

The investigator assumed that: (1) children proceed through developmental stages that are sequentially invariant and cumulative as asserted by Piaget (1964); (2) certain operations are characteristically distinctive of a developmental stage, such as class inclusion and hierarchical reclassification relationships in the concrete operational stage; (3) teachers and supervisors should design science curricula to encourage and accommodate this development; (4) the organization of learning experiences to coincide with Piagetian stages necessitates knowledge of the processes that distinguish each stage of development in such logical operations as classification.

HYPOTHESES OF THE STUDY

The hypotheses for this study were derived from the basic premise that second grade children at Piaget's concrete operational stage of intellectual development will be able to exceed the performance of the children defined at a pre-operational stage on tasks that require higher order multi-classification ability. Nine hierarchically arranged classification exercises were employed and the null hypothesis was tested for each.

The nine S-APA lessons were analyzed by the investigator and an independent judge[1] for their inherent classification properties as defined by Inhelder, Piaget (1964), Kofsky (1963), Allen (1967) and others (see table 1). Hypotheses were derived from this analysis that reflected expectations for the pre-operational and concrete operational groups on these classification

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[1] Dr. Dorothy Alfke has served as a consultant for matters dealing with the S-APA program.

lessons.

Hypothesis 1

H_1 Second grade students in a pre-operational stage of development will not differ in achievement from second grade students in the concrete operational stage after receiving instruction on each of the nine S-APA classification exercises (CE) listed below and fully described in Table 1.

Insert Table 1 here.

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1. S-APA CE-Ad (Hypothesis 1Ad)
2. S-APA CE-As (Hypothesis 1As)
3. S-APA CE-Av (Hypothesis 1Av)
4. S-APA CE-Ba (Hypothesis 1Ba)
5. S-APA CE-Bi (Hypothesis 1Bi)
6. S-APA CE-Cb (Hypothesis 1Cb)
7. S-APA CE-Cm (Hypothesis 1Cm)
8. S-APA CE-Cq (Hypothesis 1Cq)
9. S-APA CE-Cv (Hypothesis 1Cv)

Hypothesis 2

H_2 There will be no differences in performance on the competency measures on each of the nine S-APA classification exercises between second grade students in the pre-operational and concrete operational stages who were randomly assigned as matched pairs to Instructional Group X and Instructional Group Y.

Hypothesis 3

H_3 There will be no interaction between the developmental groups and the instructional groups in each of nine S-APA classification

exercises.

Definition of Terms

Classification: The process of imposing order in collections of objects or events, to show similarities, differences and interrelationships. It is the ability to abstract the common property in a group of objects or experiences and to extend the class to include all objects or experiences possessing that common property. (Lavatelli, 1970)

Consistent Sorting*: Two or more objects can be grouped together because they share some property.

Exhaustive Classes*: All objects possessing a particular property should be grouped together.

Hierarchical Reclassification*: Objects can be sorted into an all-inclusive class and then into subclasses.

Hierarchy or Learning Hierarchy*: A collection of indentified capabilities consisting of terminal behavior, its identified subordinate behaviors and the hypothesized dependencies among these behaviors.

Inclusion*: A superordinate class is larger than any one subordinate class.

Resemblance Sorting*: Two objects can be grouped together because they possess some property in common.

* The Rule statements and definitions are from Kofky (1963).

SELECTION OF THE SUBJECTS

The following three steps were used to select subjects for the defined pre-operational and concrete operational stages. Twenty of the 73 second grade children initially selected for the study (a) scored 11 or 12 on the Concept Assessment Kit-Conservation [(CAK-C), 1968]; (b) passed the conservation tasks in the order suggested by the research; and (c) passed the

four inclusion tasks of the Kofsky Classification Scale (KCS), and were therefore, defined as concrete operational.

Insert Figure 1 about here.

The remaining 53 second grade children had scored 10 or below on the CAK-C scale and had been initially defined as pre-operational. Two of these children did not pass the conservation tasks in the order prescribed in the research, and therefore, were labeled as transitional. After the administration of the KCS there remained 35 students in the pre-operational group.

Eight children who failed to score 11 or above on the CAK-C tests, but passed the four inclusion tasks of the KCS, were defined as transitional. Two children who had scored 10 and failed to conserve weight were defined as transitional. One of these children passed the inclusion tasks, while the other child did not. Both children remained in the transitional group. Due to attrition eight students who would have been part of the pre-operational group had to be dropped.

The final step in the selection process was the administering of the Otis-Lennon Mental Maturity Test, Elementary I, Form J (1967) to sixty-five children. In order to match pre-operational and concrete operational children the mental age scores were ranked from the highest to the lowest and matched within one standard error.

The experimental design necessitated dividing matched pairs of pre-operational and concrete operational at random into teacher instructional groups (X and Y). X consisted of sixteen children; eight matched pre-operational and concrete operational. Fourteen children; seven matched

pre-operational and concrete operational were assigned to Y. The sample size was limited for several reasons. The number of children available and the length of time for the administration of the individual tests by the investigators prohibited a larger sample. With a total of 30 subjects, the post-testing required a total of 51 hours; the screening of pupils into two groups even more time. A small teacher-student ratio was desired.

INSTRUCTIONAL PROCEDURES

Nine exercises from Parts A, B, and C classification hierarchy of the revised Commercial Edition (1967) of Science-A Process Approach Program considered appropriate by the developers for kindergarten, first, and second grades (AAAS, 1965, p. 16), were taught during the treatment period (Table 1).

The two elementary teachers involved in this study were experienced in using S-APA materials. One teacher had been in one of S-APA's pilot schools where the materials were field tested. The other teacher, the investigator, had used the materials as a classroom teacher and had trained teachers in the use of S-APA. The teachers cooperatively planned the instruction of each lesson.

The instructor followed the precise guidelines set forth in S-APA's teacher guide books. The instruction of each of the nine S-APA excercises took five to six instructional periods of approximately 30 to 45 minutes spanning a two week period.

The school district in which this study was conducted had adopted S-APA as its science program prior to the study. However, the subjects in this study had not yet been exposed to S-APA.

The instruction was in keeping with a basic philosophic tenet of the

new science programs; that is, active, individualized participation in the learning process, particularly, in the primary grades, is essential (Ramsey and Howe, 1969).

Due to the time and scheduling limitations, the investigator could not teach all the prerequisite lessons to the classification exercises as implied by the S-APA hierarchy. He recognizes this as an unavoidable limitation of the study.

Following the instruction of all of the nine classification exercises, S-APA's competency measures were individually administered by the investigator to all 30 children. The order in which the children were administered the competency measures was not constant, but rather the testing followed the convenience of the regular classroom teacher's schedule. Testing each child required 15 minutes for each of the exercises. The administration and scoring of the competency measures followed the outline in S-APA's teacher's exercise booklet.

ANALYSIS OF THE DATA

The raw data consisted of the competency measure achievement scores of the nine S-APA classification exercises for each of 30 children. To determine whether differences existed between the scores of the pre-operational and concrete operational groups the investigator selected the Analysis of Variance for Matched Groups (ANOVR) statistical package program from The Pennsylvania State University's Computation Center. The ANOVR program tested for the homogenity of variance, the treatment of the two main effects, developmental stages and instructional groups X and Y. As well as the interaction of the two main effects. The level of significance for retaining or rejecting the null hypothesis was set at the .05 level.

SUMMARY OF FINDINGS

There were no significant differences between the mean achievement scores of children in two development groups on the two S-APA exercises A,d and A,s which require the two lower-order classification skills (see Table 2), therefore hypotheses (H) 1A,d and H1A,s were retained.

Insert Table 2 here.

However, in S-APA classification exercises A,v; B,a; B,i; and C;m also requiring exhaustive sorting and S-APA exercises C,b; C,q; and C,v requiring hierarchical classification ability, the mean achievement scores of children in the concrete operational group were significantly higher than the mean of the children in the pre-operational group. Therefore, H1A,v through H1C,v were rejected.

Insert Table 3 here.

These findings imply that, whereas, the cognitive development of children in Piaget's concrete operational stage is such that they can comprehend both lower and higher-order classification skills, children in the pre-operational stage can master only lower-order classification skills.

In terms of teacher effect, there were no significant differences in the mean achievement scores on any of the nine S-APA classification exercises of the children assigned to the two instructional groups. There were also no significant interactions between the teacher instructional groups and the developmental groups on any of the nine S-APA exercises.

These findings imply that achievement on the S-APA exercises were the result of dependency on the developmental stage at which the children were functioning and not upon teacher effect. Hence, the variance in achievement between pre-operational and concrete operational groups could be associated with the limitations of logical thinking present in children in the pre-operational stage. H_2 and H_3 were retained.

DISCUSSION

Both developmental groups were equally successful on the two S-APA exercises requiring resemblance and consistent sorting. This finding confirms Piaget's et al. assertion that resemblance and consistent sorting are lower classification skills and should be mastered by the time children are in second grade. What is perplexing, however, are the significant differences between the means of the two developmental groups on S-APA exercises A,v; B,a; B,i; and C,m (see Table 1) representing lessons designed by S-APA for kindergarten, first and second grades, age levels represented predominately by pre-operational children. One would have expected to find results similar to that of earlier lessons, S-APA A,d and A,s (see Table 2).

The research regarding the order in which exhaustive sorting ability emerges is conflicting, however. Kofsky (1963) verified Piaget's and Inhelder's research when she found that exhaustive class sorting appeared immediately following consistent and resemblance sorting abilities. Ninety percent of the children seven years and older in Kofsky's study were able to carry out exhaustive class sorting tasks. However, Allen's (1967) research, although agreeing substantially with the predicted order of Piaget, Inhelder and Kofsky; differs in respect to exhaustive class sorting. Allen found that children were unable to sort exhaustively until somewhat later in the sequence of classification behavior. No higher than 65 percent of second, third and fourth grade children were able to sort

exhaustively.

Annett's (1959) study indicated it was not until after eight years of age that children could sort exhaustively. This study confirms Allen's and Annett's findings that exhaustive sorting may appear somewhat later than predicted by Piaget and Inhelder.

Inhelder and Piaget (1964), Ginsburg and Opper (1968), and Kamaii (1969) indicated children in the concrete operational stage should be able to carry out higher-order classification skills; namely, hierarchical classification skills. This would imply that concrete operational children would be more successful than pre-operational children on S-APA classification exercises C,b; C,q; and C,v, employing hierarchical classification skills. The findings of this study support the theorists who suggest that children possessing the mental operations characterizing the concrete operational stage are able to form higher-order multi-classification tasks.

IMPLICATIONS

Science curriculums based on Piagetian theory have appeared just within the last decade. This study implies that the developmental stages of children should be considered a factor in the sequencing of cognitive expectations in curricula such as S-APA.

Children at different cognitive developmental stages may find specific skills beyond their level of comprehension if adequate sequences of prerequisites are not provided. Therefore, curriculum specialists and evaluators at the district and state levels should be continuously organizing and evaluating new curriculum materials for their appropriateness to such variables as the developmental stage of children.

Teachers should realize that elementary age children studying science

lessons employing process skills need individualized instruction just as they do in any other subject area. If the suggestion for more individualization of learning is followed, the elementary classroom teacher would need to: (1) diagnose children's level of development with Piagetian instruments, (2) structure the lessons to the comprehension of the children's development stage or slightly beyond that stage to challenge the child, (3) provide practice in manipulating and interacting with a variety of potentially novel scientific objects both in groups with other children or individually, and (4) prepare additional process lessons that may act as prerequisites to higher-order process skills.

Since it seems the stages of development at which a child is functioning has some bearing on his achievement, teachers should be prepared in facilitating success and improvement through carefully sequencing prerequisite skills.

LIMITATIONS

1. Not all the prerequisite skills from S-APA processes other than classification were taught to the subjects. Because of the hierarchical nature of S-APA, this may have affected the results of the study.
2. The subjects selected for this study came from a predominately professional community of Central Pennsylvania. These children may not be representative of a cross-section of school populations, and, thus, the results of this study could be generalizable only to similar school communities.

RECOMMENDATIONS FOR FURTHER RESEARCH

1. The basic study should be replicated with the following alternatives included in the design:
    a. A larger sample of children, including those from urban and rural

areas.

b. A longer treatment period to teach and/or diagnoses for competency of all the prerequisites to S-APA's classification hierarchy.

c. A control group of children who would not have been exposed to the S-APA classification lessons should be added.

d. Kindergarten and first grade children should be involved.

2. Similar studies could be conducted using the classification exercises of ESS and SCIS.

3. Similar research could investigate additional S-APA process hierarchies such as measurement.

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Table 1

Nine S-APA Classification Exercises Tested

Identification of S-APA Exercise	Classification Skills Required*	Name of S-APA Exercise	Coding (Referred to hereafter as)
Part A,d	Resemblance sorting Consistent sorting	Classifying Leaves, Nuts and Shells	CE-Ad
Part A,s	Resemblance sorting Consistent sorting Exhaustive sorting	Purposes of Classification	CE-As
Part A,v	Resemblance sorting Consistent sorting Exhaustive sorting	Classifying Animals	CE-Av
Part B,a	Resemblance sorting Consistent sorting Exhaustive sorting	Observing Living and non-living things	CE-Ba
Part B,i	Resemblance sorting Consistent sorting Exhaustive sorting	Variations of Objects of the same kind	CE-Bi
Part C,b	Resemblance sorting Consistent sorting Exhaustive sorting Hierarchical reclassification	Kinds of Living Things in an Aquarium	CE-Cb
Part C,m	Resemblance sorting Consistent sorting Exhaustive sorting	Solids, Liquids and Gaseous State of Matter	CE-Cm
Part C,q	Resemblance sorting Consistent sorting Exhaustive sorting Dual class membership Hierarchical reclassification	Color Wheel	CE-Cq
Part C,v	Consistent sorting Exhaustive sorting Hierarchical reclassification	Separating Materials from Mixtures	CE-Cv

Figure 1

FLOW DIAGRAM OF SELECTION OF SUBJECTS FOR PRE-OPERATIONAL AND CONCRETE OPERATIONAL GROUPS

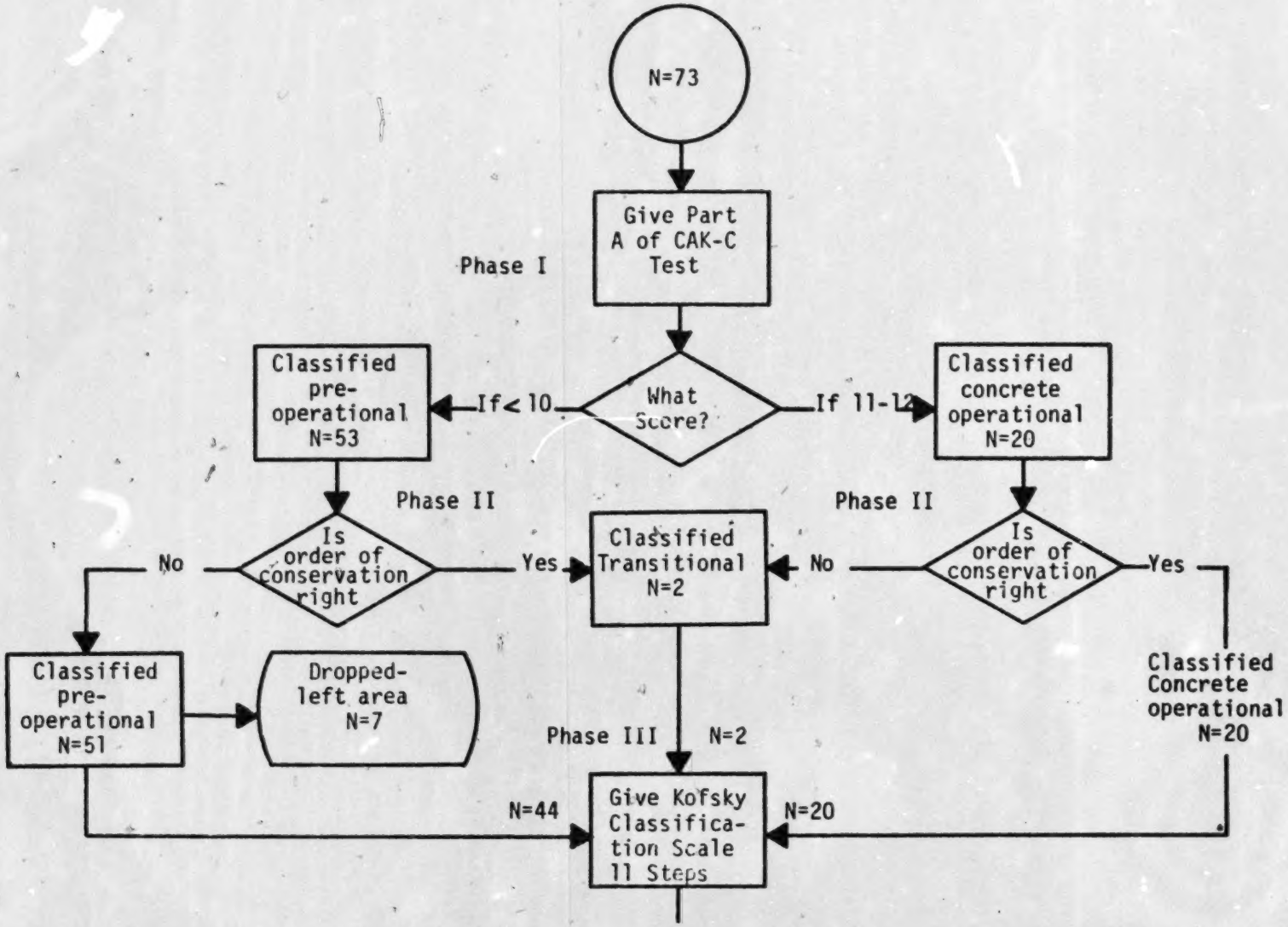

Figure 1 (cont'd.)

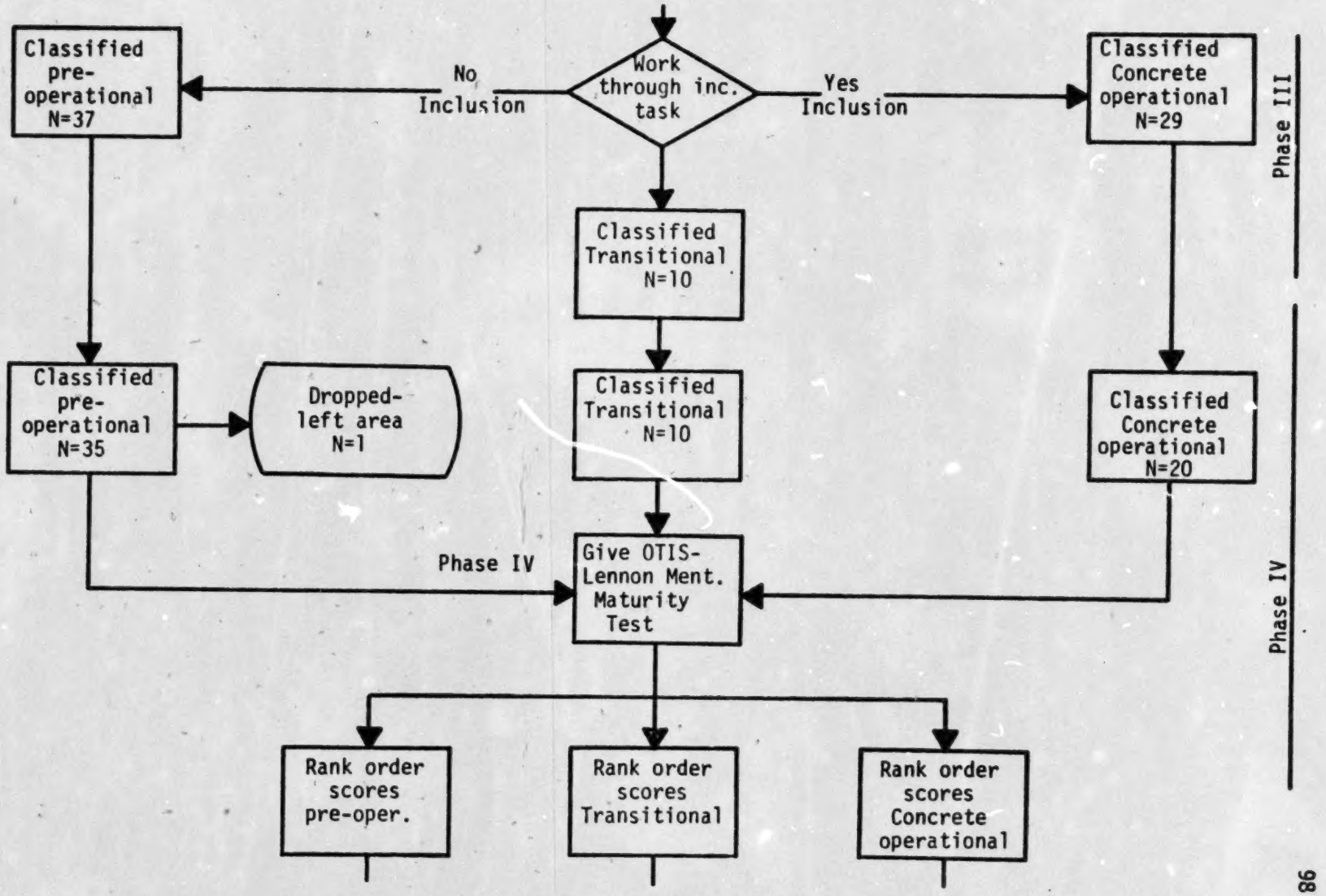

Figure 1 (cont'd.)

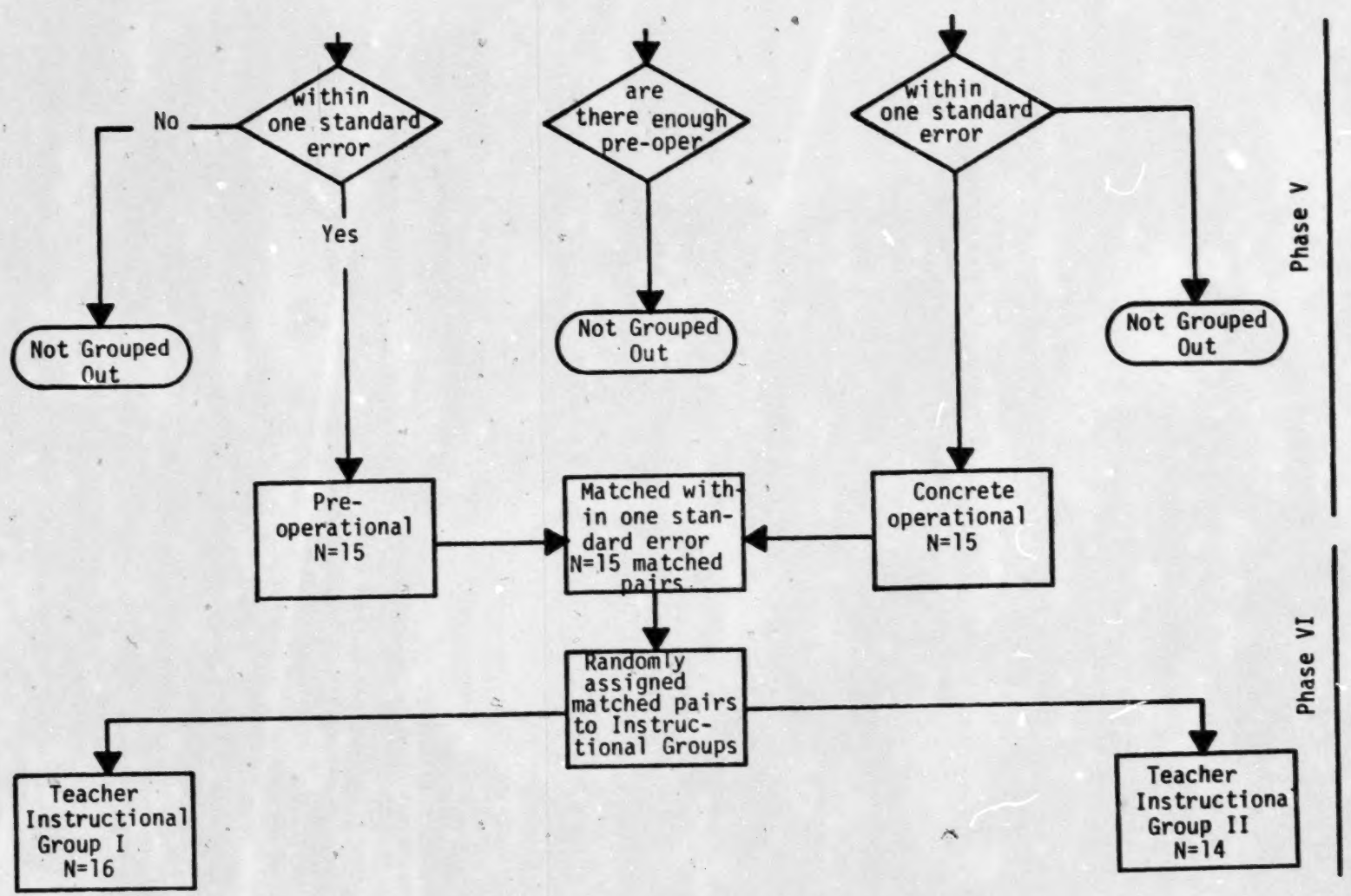

Table 2
Summary of Analysis Variance for Nine S-APA Classification Exercises
(A-Instructional Groups; B-Developmental Groups; C-Interaction)

S-APA Exercise	Source	S.S.	M.S.	DF	F-ratio	Probability
1. CE-A,d	A	.095	.095	1	.02	.89
	Error	.585	.045	13		
	B	.133	.133	1	.99	.34
	C	.116	.116	1	.87	.37
	Error	1.75	.134	13		
2. CE-A,s	No analysis necessary as all 15 students in both developmental groups obtained perfect scores of 3.0 on this exercise.					
3. CE-A,v	A	.054	.054	1	.005	.94
	Error	1.38	.106	13		
	B	14.7	14.7	1	19.37**	.001
	C	1.93	1.93	1	2.55	.13
	Error	9.87	.759	13		
4. CE-B,s	A	.095	.095	1	.067	.08
	Error	.185	.014			
	B	1.20	1.20	1	5.98*	.02
	C	.193	.193	1	.962	.34
	Error	2.60	.201	13		
5. CE-B,i	A	.402	.402	1	2.12	.17
	Error	2.46	.190	13		
	B	1.63	1.63	1	8.62*	.01
	C	.402	.402	1	2.12	.17
	Error	2.46	.189	13		
6. CE-C,b	A	12.34	12.34	1	1.87	.20
	Error	85.86	6.60	13		
	B	56.03	56.03	1	6.73*	.02
	C	2.29	2.29	1	.28	.61
	Error	108.18	8.32	13		
7. CE-C,m	A	6.31	6.31	1	3.71	
	Error	22.15	1.70	13	60	.08
	B	38.53	38.53	1	24**	.000
	C	.101	.101	1	.06	.80
	Error	20.37	1.57	13		
8. CE-C,q	A	.57	.57	1	.33	.57
	Error	22.29	1.71	13		
	B	20.83	20.83	1	11.45**	.005
	C	.149	.149	1	.008	.93
	Error	23.65	1.82	13		

*Significant at 0.05 F at .05 with 1,13 df=4.67
**Significant at 0.01 F at .01 with 1,13 df=9.07

9. CE-C,v	A	.018	.00	1	.00	1.0
	Error	59.86	4.98	12		
	B	46.29	46.29	1	13.00**	.004
	C	.111	0.00	1	0.0	1.0
	Error	42.71	3.56	12	0.0	

*Significant at 0.05 F at .05 with 1,12 df=4.75
**Significant at 0.01 F at .01 with 1, 12 df=9.33

Table 3

Table of Specification of Classificatory Behaviors
Found in S-APA Classification Exercises

1967 Commercial Edition Titles	Part	Resemblance Sorting	Consistent Sorting	Exhaustive Classes	Conservation of Class	Dual Class Membership	Horizontal Reclassification	Hierarchical Reclassification	"Some" and "All"	Whole is the Sum of Its Parts	Conservation of Hierarchy	Inclusion
Classifying Leaves, Nuts, and Shells	A,d	*[A]	*	P								
A Purpose of Classification	A,s	*	*	*								
Classifying Animals	A,v	*	*	*		P	P					
Observing Living and Non-Living Things	B,a	*	*	*[A]								
Variations of Objects of the Same Kind	B,i	*	*	*[A]								
Kinds of Living Things in an Aquarium	C,b	*	*	*				*[A]				
Solids, Liquids and Gaseous State of Matter	C,m	*	*	*[A]								
Color Wheel	C,q	*	*	*		*		*				
Separating Materials from Mixtures	C,v		*	*				*				

*Main emphasis of lesson.

[A]Indicates Allen's (1967) analysis of S-APA exercise.

[P]Possible classification emphasis.